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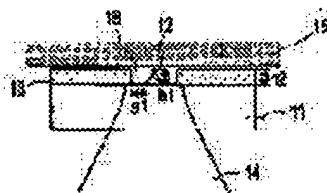
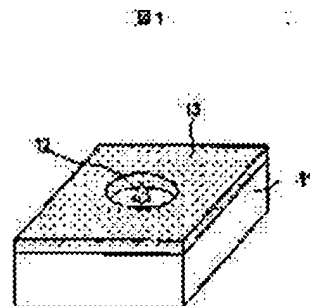
(72)Inventor : MATSUMOTO TAKUYA  
 SHIMANO TAKESHI  
 HOSAKA SUMIO  
 ISSHIKI FUMIO

(54) NEAR-FIELD OPTICAL PROBE AND NEAR-FIELD OPTICAL MICROSCOPE USING IT AND OPTICAL RECORDING/REPRODUCING DEVICE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a near-field optical probe capable of heightening light utilization efficiency, executing high-speed scanning, and reducing background light included in detected light, and its manufacturing method.

SOLUTION: A metal scatterer 12 having a shape of a circular cone or a poly-angular pyramid or a plane ellipsoid or a triangle is formed on a substrate 11, and a film 13 made of metal or dielectric or semiconductor or the like having the same film thickness as the height of the scatterer is formed on the periphery of the scatterer.



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## CLAIMS

[Claim(s)]

- [Claim 1] The approaching space light probe characterized by having the scatterer of the metal with which the shaft carried out the configuration of a cone perpendicular to a substrate front face, or a multiple drill on the substrate.
- [Claim 2] The approaching space light probe characterized by having the scatterer of the metal which carried out the die length of a major axis and a minor axis, and the configuration of a flat-surface ellipsoid where thickness was below light wave length, on the substrate.
- [Claim 3] The approaching space light probe characterized by having the scatterer of the metal with which thickness and the radius of curvature of top-most vertices carried out the configuration of the triangle below light wave length on the substrate.
- [Claim 4] The radius of curvature of the inside of three top-most vertices of said triangle and two top-most vertices is an approaching space light probe according to claim 3 characterized by being larger than the radius of curvature of the one remaining top-most vertices.
- [Claim 5] The radius of curvature of the hole of the part which joined the film of said flat-surface top triangle and its perimeter, and carried out the joint part is an approaching space light probe according to claim 3 characterized by being larger than the radius of curvature of triangular top-most vertices.
- [Claim 6] The approaching space light probe characterized by spacing of the top-most vertices where the metal membrane which carried out the configuration to which the point was radicalized on the substrate, and the metal membrane of the configuration of arbitration were radicalized, and another metal membrane being several 10nm.
- [Claim 7] The approaching space light probe with which two metal membranes which carried out the configuration to which the point was radicalized on the substrate are characterized by spacing of each top-most vertices being several 10nm.
- [Claim 8] An approaching space light probe given in seven from claim 1 characterized by having the metal membrane, dielectric film, or semi-conductor film which has the same thickness as the height of scatterer around said scatterer.
- [Claim 9] The approaching space light probe according to claim 8 which said film has protection-from-light nature, and is characterized by spacing of scatterer and the film of the perimeter being below light wave length.
- [Claim 10] An approaching space light probe given in seven from claim 1 characterized by for the depth having formed the hollow equal to the height of scatterer in the substrate front face, and forming metaled scatterer all over the hollow.
- [Claim 11] An approaching space light probe given in ten from claim 8 characterized by filling with an ingredient with light transmission nature between the hollows formed between said scatterers and film of the perimeter, or in a substrate front face.
- [Claim 12] Said substrate is an approaching space light probe given in 11 from claim 1 characterized by the hemispherical thing.
- [Claim 13] An approaching space light probe given in 11 from claim 1 characterized by preparing a condensing component on said substrate.
- [Claim 14] Said condensing component is an approaching space light probe according to claim 13 characterized by being a holographic lens.
- [Claim 15] An approaching space light probe given in 11 from claim 1 characterized by forming the scatterer of said metal in the end face of an optical resonator.
- [Claim 16] An approaching space light probe given in 11 from claim 1 characterized by forming the scatterer of said metal in the outgoing radiation opening end face of semiconductor laser.
- [Claim 17] The approaching space light probe characterized by forming the metal membrane which made configurations in which the point was radicalized, such as a flat-surface ellipsoid and a triangle, the substrate side face or the substrate side face deleted aslant so that radicalized top-most vertices may touch a sample front face.
- [Claim 18] The approaching space light probe according to claim 17 characterized by covering the metal membrane formed in said substrate side face with a transparent dielectric.
- [Claim 19] The approaching space optical microscope characterized by using an approaching space light probe given in 18 from claim 1
- [claim 20] The optical recording/regenerative apparatus characterized by using an approaching space light probe given in 18 from claim 1
- [claim 21] The approaching space optical microscope, and the optical recording/regenerative apparatus characterized by using the regulating approach of a focal location of adjusting the focal location of incident light by separating a part of light which carries out incidence to an approaching space light probe, carrying out incidence to the pattern for focal justification which formed the light beside the approaching space light generation source, and measuring the configuration of the reflected light from there.
- [Claim 22] The approaching space optical microscope according to claim 21, and the optical recording/regenerative apparatus which is made to carry out incidence of the return light from said pattern for focal justification to a convex lens and a cylinder lens, and is characterized by using the regulating approach of a focal location of performing alignment of a direction perpendicular to a substrate front face by measuring the distortion of the shape of beam at that time.
- [Claim 23] As said pattern for focal justification, width of face a long and slender slot smaller than the diameter of an optical spot Two Form so that the sense may intersect perpendicularly mutually, and incident light is divided into three, and one is made to carry out incidence to an approaching space light generation source among those. Remaining two are made to carry out incidence to a part for the core of two slots. The approaching space optical microscope according to claim 21, and the optical recording/regenerative apparatus characterized by using the regulating approach of a focal location of performing focal alignment by measuring the quantity of light of two bright parts contained in the pattern of the reflected light from two slots.

[Claim 24] The optical recording/regenerative apparatus characterized by using the record disk with which the approaching space light probe was built in the interior of a cartridge.

[Claim 25] The optical recording/regenerative apparatus according to claim 24 characterized by using the record disk with which it has a revolving shaft in a corner of a cartridge, the arm was attached in the revolving shaft, and the approaching space light probe was attached in the arm through the suspension.

[Claim 26] The optical recording/regenerative apparatus according to claim 24 characterized by joining the arm in which the optical head which carried the light source and a photodetector in the revolving shaft with which said arm was attached was attached, interlocking with [ probe / approaching space light ] an optical head, making it move, and introducing the light from an optical head into an approaching space light probe through the aperture attached in the cartridge.

[Claim 27] Optical recording/regenerative apparatus given in 26 from claim 25 characterized by using the projection of the shape of a V groove and a semi-sphere for junction of the arm connected with the arm connected with said approaching space light head, and the optical head.

[Claim 28] The optical recording/regenerative apparatus characterized by using the record disk which prepared the metal membrane layer in the bottom of a recording layer.

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## DETAILED DESCRIPTION

## [Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention is set to the optical recording/regenerative apparatus which used an approaching space optical microscope or approaching space, and relates to the optical probe which generates or detects approaching space light.

[0002]

[Description of the Prior Art] Light makes it condense in the conventional optical microscope using a lens. In this case, resolution is restricted by light wave length. On the other hand, a dimension uses the microstructure of nano meter order, a path uses minute opening below light wave length, and light is made to condense instead of a lens in an approaching space optical microscope. If light is applied to this microstructure, the light which is called approaching space light near [ that ] the microstructure and which carried out localization will occur. The configuration and optical property of a sample can be measured with the resolution decided by the dimension of microstructure by bringing this approaching space light close near the sample, and making a sample front-face top scan. This microscope is beginning to be applied to broad fields, such as configuration measurement of a biological material, semi-conductor quantum structure, polymeric materials, etc., and a spectrum, high density optical recording, in recent years.

[0003] As structure (approaching space light probe) of generating approaching space light, the radicalized optical fiber (optical fiber probe) with minute opening below light wave length is used widely. This fiber probe is produced by coating with a metal except a tip, after being radicalized by extending the end of an optical fiber, heating or using a chemical etching method. By introducing light into an optical fiber, approaching space light can be generated near the minute opening formed at the tip.

[0004] However, the above-mentioned fiber probe has the fault that efficiency for light utilization is low. For example, when the diameter of opening is 100nm, the ratio of the luminous intensity which carries out incidence to a fiber, and the luminous intensity which carries out outgoing radiation from a fiber tip is 0.001% or less. The following probes are proposed in order to conquer this trouble. Multistage story radicalization fiber probe : (1) The kurtosis angle at the tip of a fiber The fiber probe changed to two steps or a three-stage as it went at a tip from a root () [ Applied Physics Letters, applied (Japanese name) physics Letters, Vol.68, No 19, p2612-2614, ] [ 1996; ] Applied Physics Letters, applied (Japanese name) physics Letters, Vol.73, No.15, and p2090- 2092 and 1998. (2) Metal needle probe : use the needle of STM as a probe. By irradiating light at the tip of a needle, a strong approaching space light is generated near the tip. Minute-with (3) metal minute ball opening fiber probe: (JP,6-137847,A) The fiber probe with which the metaled minute ball was formed in the core of minute opening at a tip (it proposes by artificers JP,11-101809,A and for a start [ this ]). Plasmon is excited in a metal minute ball by the light which carried out outgoing radiation from minute opening, and an approaching space light strong against metal spherical neighborhood occurs. (4) The piece probe of glass by which the metal coat was carried out : form a metal membrane with a thickness of about 50nm in glass Kataue who started in the shape of the triangle pole, and make him excite surface plasmon on the metal membrane. Surface plasmon is spread toward top-most vertices, and a strong approaching space light generates it near the top-most vertices (7984 Physical Review B, the physical (Japanese name) review No [ B, Vol55, and ] 12, and p7977- 1997). (5) A metaled glass substrate probe with scatterer : the probe which attached metaled scatterer to the glass substrate base. A strong approaching space light generated near the metaled scatterer is used (JP,11-250460,A).

[0005] By the way, it is necessary to make into several nm - 10nm of numbers spacing on the microstructure which generates approaching space light, and the front face of a sample in an approaching space optical microscope. Then, when using the probe which consisted of above-mentioned optical fibers and pieces of glass, the special control system for controlling spacing on the end of the probe and the front face of a sample is needed. Generally spacing is measured using the force between atoms committed between the end of the probe and a sample, and servo control is performed using the measured value.

[0006] However, since a limitation is in a servo band when using the above-mentioned servo control, there is a limitation in the scan speed of a probe. It is necessary to make a high speed scan a probe on a record disk, and spacing fluctuation of the high frequency produced from distortion and inclination of a disk cannot be controlled by the above-mentioned controlling method in the optical recording/regenerative apparatus with which a high data transfer rate is demanded especially. Then, the following probes are proposed in order to solve this problem. (1) Flat-surface opening probe : the probe in which \*\*\*\* opening for anisotropic etching was formed into the silicon substrate (The Pacific Rim Conference on Lasers and Electro-Optics, the Pacific Rim (Japanese name), KONFERENSUON laser ANDOEREKUROTO optics, and WL2,199). Since the minute opening periphery is flat, spacing can be kept constant by pushing a probe against a sample. (2) An opening probe with a pad : the probe which formed in the glass substrate base the projection of the square drill which has minute opening at a tip, and formed the pad around the projection (JP,11-265520,A). With a pad, spacing of the end of the probe and a sample is kept constant. (3) A surface emission-type laser probe with a metal minute chip : form metaled minute opening and a metaled minute projection in a surface emission-type laser outgoing radiation opening end face (1383 the application physics Vol68 and No12, p1380- 1999). Since structure is flat, spacing can be kept constant by pushing a probe against a sample. Since it also has a metaled minute projection and resonator structure, improvement in effectiveness is also expected.

[0007]

[Problem(s) to be Solved by the Invention] It is that : (1) efficiency for light utilization as which the following three points are required as engine performance of an approaching space light probe is high, and that (2) rapid scanning is possible. (3) In order for the background light contained in the light detected to gather little thing efficiency for light utilization, some approaches are proposed as mentioned above.

Although the fiber probe which changed the acute angle at a tip into the multistage story has 100 times higher effectiveness from 10 compared with the fiber probe currently generally used, it is still inadequate for application as which the high effectiveness in which 10% or more of efficiency for light utilization is required, such as optical recording/playback, is required. Moreover, since the optical fiber is used, it is mechanically weak, and rapid scanning is impossible. The metal needle probe, the minute-with metal minute ball opening fiber probe, the piece probe of glass by which the metal coat was carried out, and the metaled glass substrate probe with scatterer are all raising effectiveness using a metaled property, and can expect high effectiveness. However, the end of the probe is carrying out the weak configuration for all mechanically, and rapid scanning is not turned to. Especially a metal needle probe and the metaled glass substrate probe with scatterer have the light which does not shine upon a needle tip or scatterer, and the trouble that many background light will be detected in order to carry out incidence to a sample.

[0008] The probe in which rapid scanning is possible is also proposed partly as mentioned above. In the case of a flat-surface opening probe and an opening probe with a pad, rapid scanning is possible, but efficiency for light utilization is small. The surface emission-type laser probe with a metal minute projection is rapid scanning, efficiency for light utilization is also high and background light is also expected are few. However, although it is necessary to optimize a metaled configuration in order to generate a strong approaching space light using a metaled minute projection, nothing is indicated about a configuration. Moreover, it is not indicating about the manufacture approach.

[0009] The approaching space light probe which fills three above-mentioned demands of this invention, i.e., efficiency for light utilization, is expensive, rapid scanning is possible, and the background light contained in the light detected aims at offering few approaching space light probe and its manufacture approach. It aims at offering the incidence approach of the configuration of the optimal scatterer for it, and the light to a probe for the purpose of raising efficiency for light utilization by using the scatterer of the metal which has a dimension below light wave length especially.

[0010]

[Means for Solving the Problem] The approaching space light probe of this invention is constituted by film, such as a metal with the same thickness as the height of the scatterer of the metal which carried out configurations, such as a substrate, a cone formed on it, and a triangle, and the scatterer formed around the scatterer, a dielectric, or a semi-conductor. Metaled scatterer serves to generate a strong approaching space light, and the film of the perimeter serves to prevent damaging scatterer, when bringing a probe close to a sample and making a high speed scan it. Moreover, it can serve to reduce background light by making the membranous quality of the material into a thing with protection-from-light nature, and making spacing of scatterer and the film below into light wave length. In order to prevent breakage of scatterer, it may change to forming the film, the depth may form a hollow equal to the height of scatterer in a substrate front face, and metaled scatterer may be formed all over the hollow. Moreover, in order to reduce the probability of scatterer breakage further, between the hollows formed between said scatterers and film of the perimeter or in a substrate front face may be filled with the film with light transmission nature.

[0011] The configuration of metaled scatterer is made into a cone, a multiple drill, an ellipse, and a triangle. When making the configuration of scatterer into a triangle, the radius of curvature of two top-most vertices may be made larger than the radius of curvature of the one remaining top-most vertices among three triangular top-most vertices. Moreover, the triangular film and the triangular film of a perimeter may be joined. In this case, it is made for the radius of curvature of the hole of the part which carried out the joint part to become larger than the radius of curvature of triangular top-most vertices. Moreover, the metal membrane which carried out configurations in which the point was radicalized, such as a flat-surface ellipsoid or a triangle, as scatterer may be formed on a substrate, and near [ the ] the radicalized top-most vertices, the film of another metal may be formed so that spacing of top-most vertices and a metal membrane may become below light wave length. It is good to form two metal membranes which carried out the configuration in which the point was radicalized especially so that spacing of two radicalized top-most vertices may be set to several 10nm or less. In addition, when using the metal membrane which carried out configurations in which the point was radicalized, such as a triangle and an ellipsoid, as scatterer, these metal membranes may be formed in a substrate side face.

[0012] The above-mentioned flat-surface substrate may be replaced with a hemispherical substrate in order to make small the diameter of a spot in the condensing point of incident light. Moreover, a holographic lens etc. may prepare a condensing component on a substrate. Moreover, metaled scatterer may be formed in the outgoing radiation opening end face of an optical resonator or semiconductor laser. Moreover, when using the film of a flat-surface ellipsoid or a triangle as scatterer, the film of a flat-surface ellipsoid or a triangle may be formed in a substrate side face or the substrate side deleted aslant so that only one top-most vertices of a flat-surface ellipsoid or a triangle may touch a sample front face.

[0013] The film formation process with which the manufacture approach of the approaching space light probe of this invention forms film, such as a metal, a dielectric, or a semi-conductor, on a substrate, The resist spreading process which forms the resist film on the film, and exposure and the development process of removing the resist film of the part which forms scatterer, It is characterized by having the membranous etching process of removing membranous [ some ], the scatterer formation process which forms metaled scatterer in the part from which the resist was removed, and the resist removal process of removing the resist film. In addition, when manufacturing the scatterer of the shape of the shape of a cone, and a multiple drill, below light wave length having a circular diameter or one side makes the configuration of a part of removing a resist the multiple drill below light wave length, and in a scatterer formation process, a metal is thickly vapor-deposited until the circular hole is closed. Moreover, in said approaching space light probe making process, except for a film formation process, it may change to a membranous etching process and the etching process of the substrate which etches a substrate may be put in.

[0014] Moreover, the film formation process which forms film, such as a metal, a dielectric, or a semi-conductor, on a substrate at manufacture of the approaching space light probe of this invention, The hollow formation process which removes a part of the film by a photolithography etc., The resist spreading process which forms the resist film, and exposure and the development process of removing the resist film of the part which forms scatterer, The manufacture approach characterized by having the scatterer formation process which forms scatterer, and the resist removal process of removing the resist film may be used for the part from which the resist was removed.

[0015] Moreover, in said production process, it may change to the hollow formation process which removes membranous [ some ], and the hollow formation process which forms a direct hollow in a substrate front face with photolithography etc. may be put in.

[0016] Moreover, you may manufacture using the approach characterized by having the metal membrane formation process which forms a metal membrane on a substrate, the resist spreading process which forms the resist film on it, exposure and the development process of removing the perimeter resist of the part which forms scatterer, the etching process of the metal membrane which removes the metal

membrane of a part which removed the resist, and the resist removal process of removing a resist.

[0017] Moreover, you may manufacture using the approaching space light probe approach characterized by having the resist spreading process which forms the resist film on a substrate, exposure and the development process of removing the resist around the part which forms scatterer, the metal vacuum evaporation process which forms scatterer, and the resist removal process of removing a resist.

[0018] Moreover, after the approaching space light probe from which said scatterer was protected by the dielectric forms scatterer and the film of the perimeter, it is produced by the manufacture approach characterized by having the dielectric film formation process which forms a dielectric film upwards, and the dielectric film polish process which grinds a dielectric film so that a scatterer tip may come out to a front face.

[0019] In addition, although it is necessary to make it the focal location of incident light come to the location of \*\*\*\*\* in case light is introduced into the approaching space light probe of this invention For that purpose, by separating a part of light which carries out incidence to an approaching space light probe, carrying out incidence to the pattern for focal justification which formed the light beside the approaching space light generation source, and measuring the configuration of the reflected light from there The regulating approach of the focal location characterized by adjusting the focal location of incident light is used. Especially the alignment of a direction perpendicular to a substrate front face Incidence of the return light from said pattern for focal justification is carried out to a convex lens and a cylinder lens, and it carries out by measuring the distortion of the shape of beam at that time. To the alignment of a direction parallel to a substrate front face as a pattern for focal justification The long and slender slot where width of face is smaller than the diameter of an optical spot is formed so that 2 and the sense may intersect perpendicularly mutually. Incident light is divided into three, one is made to carry out incidence to an approaching space light generation source among those, remaining two are made to carry out incidence to a part for the core of two slots, and it carries out by measuring the quantity of light of two bright parts contained in the pattern of the reflected light from two slots.

[0020] By the way, to apply the above-mentioned approaching space light probe to exchangeable optical recording/regenerative apparatus of a disk, it is necessary to prevent dirt and the blemish on the front face of a disk. Then, the optical recording/regenerative apparatus of this invention are characterized by building the approaching space light probe in the interior of the cartridge which protects a record disk. Have a revolving shaft in a corner of a cartridge and an arm is attached in the revolving shaft. An approaching space light probe is attached in the arm through a suspension. The arm in which the optical head which carried the light source and a photodetector in the revolving shaft with which this arm was attached was attached is joined. An optical head is interlocked with an approaching space light probe, it is made to move, and the light from an optical head is introduced into an approaching space light probe through the aperture attached in the cartridge. The projection of the shape of a V groove and a semi-sphere is used for junction of the arm connected with the arm connected with said approaching space light head, and the optical head. In addition, when using the metal membrane which carried out configurations in which the point was radicalized, such as a triangle, an ellipse, etc. which were formed in the projection of the metal which carried out the configuration of a cone or a multiple drill as scatterer, or the substrate side face, in order to raise resolving power and effectiveness, it is good to prepare a metal membrane layer in the bottom of the recording layer of a record disk.

[0021]

[Embodiment of the Invention] The gestalt of concrete operation of this invention is explained below.

[0022] The approaching space light probe of this invention consists of film 13 which consists of the metal formed in the perimeter of the scatterer 12 of a metal with the substrate 11 with light transmission nature, drawing 2, or a configuration like drawing 3, and scatterer, a dielectric, a semi-conductor, etc., as shown in drawing 1. A substrate 11 consists of a quartz and scatterer 12 consists of gold or silver. Moreover, the film 13 consists of gold, silver, titanium, or silicon.

[0023] Scatterer 12 serves to generate a strong approaching space light. As shown in drawing 1 (b), incidence of the light 14 condensed with the lens etc. is carried out to a substrate, and it shines upon scatterer 12. At this time, light 14 is scattered about with scatterer 12 and the approaching space light which has a high space fourier frequency component near the scatterer generates them. Since approaching space light reinforcement becomes so large that the dispersion effectiveness of scatterer is high, a strong approaching space light occurs near the scatterer of a metal with high dispersion effectiveness.

[0024] In case the film 13 brings scatterer close to about 15 sample, it serves to prevent scatterer's colliding and being destroyed by the sample front face. Therefore, it is necessary to make equal the thickness  $h_1$  of the film 13, and the height  $h_1$  of scatterer 12. In addition, instead of forming the film, in order to prevent destruction of scatterer in this way, when only the same depth  $h_3$  as the height  $h_1$  of scatterer investigates a substrate like drawing 4 (a), it may become depressed, and 21 may be formed, and scatterer may be formed there. Furthermore, as shown in drawing 4 (b) and (c), the inside of the impression formed between the film and scatterers or in a substrate may be filled with a dielectric 22. Thereby, the probability of destruction of scatterer decreases further.

[0025] By the way, when forming the above-mentioned film 13, it is desirable to make the quality of the material into a thing (what reflects or absorbs light) with protection-from-light nature, such as a metal and a semi-conductor, and to make it the spacing  $S_1$  of scatterer 12 and the film set to several 100nm or less. For example, an ingredient is used as gold, titanium, silicon, etc. and spacing  $S_1$  is set to 50nm. Thus, by making the film into a thing with protection-from-light nature, the contrast of an image or a regenerative signal can also be raised in the configuration of a sample, measurement of an optical property, and playback of the record mark in optical recording/regenerative apparatus. namely, the time of applying light to scatterer 12 -- a diffraction limitation sake -- the beam diameter of light -- scatterer and until comparable -- it cannot be made small. Therefore, incidence of a part of light is carried out to a sample 15 as a background light, without being scattered about. Consequently, the rate of light which has the space fourier frequency component of a low degree in a sample among the light which carries out incidence will become large, and the contrast of an image or a regenerative signal will fall. Here, by forming the film with protection-from-light nature so that the distance  $s_1$  of scatterer 12 and the film 13 may become below light wave length, the light which does not shine upon scatterer 12 can be made to be able to reflect or absorb, and the quantity of light of the background light which carries out incidence to a sample 15 can be reduced.

[0026] In addition, when the membranous quality of the material is a metal and the membranous quality of the material is except metals, such as a dielectric, although it is necessary to vacate spacing of scatterer and a metal membrane, the film may be formed so that the film 23 and scatterer 12 may touch like drawing 4 (d).

[0027] The configuration of the above-mentioned scatterer 12 is made into a cone or a multiple drill like drawing 2 (a). If light carries out incidence to this scatterer, an approaching space light strong against about 61 top-most vertices will occur. The radius of curvature, the height  $h_6$ , and distance across vee (diameter)  $d_1$  of top-most vertices 61 set 20nm and height to 100nm, and set distance across vee to 100nm for the radius of curvature of top-most vertices. Although the radius of curvature of top-most vertices should just be 50nm or less,

the smaller one is desirable in order to obtain high resolution. Although height and distance across vee should just be several 100nm or less, as for the ratio of the radius of curvature of top-most vertices, height, and distance across vee, it is desirable to adjust so that the after-mentioned plasmon may be excited.

[0028] the configuration of scatterer -- drawing 2 (b) -- like -- a flat-surface ellipsoid (a circle is included) -- even if -- it is good. The die length and thickness of a major axis and a minor axis set the die length of 150nm and a minor axis to 50nm, and set thickness to 40nm for the die length of a major axis. Although the value of a major axis and a minor axis should be several 100nm or less and thickness should just be 100nm or less, as for the ratio of those values, it is desirable to double with the excitation conditions of the after-mentioned plasmon. If light carries out incidence to the film of this flat-surface ellipsoid, an approaching space light strong against the top-most vertices 62 of the flat-surface ellipsoid on a shaft parallel to the polarization direction 63 of light will occur. In order to generate a strong approaching space light especially, it is desirable to use the polarization direction of light as the major axis of an ellipse at parallel.

[0029] Moreover, the configuration of scatterer is good as for a film-like triangle 70 like drawing 2 (c). The triangular radius of curvature and the thickness of one top-most vertices 64 set the radius of curvature of top-most vertices to 15nm, and set thickness to 30nm. The radius of curvature of top-most vertices should be 100nm or less, and thickness should just be 100nm or less. As for the kurtosis angle of top-most vertices, it is desirable to double with the excitation conditions of the after-mentioned plasmon. If they are irradiated as the top-most vertices 64 where the polarization direction 63 was radicalized in light are turned to, in order that an electron may focus on about 64 keenly radicalized top-most vertices, an approaching space light strong there occurs. the approaching space light distribution generated near the metal membrane when a film-like triangle is made to carry out incidence of the light to drawing 5 -- FDTD -- the result calculated using law (Journal of Optical Society of America A, Vol. 12, No. 9, p1974-1983, 1995, JANARUOBU (Japanese name) optical society OBUAMERIKAA) is shown. this count is shown in drawing 5 (a) -- as -- the magnitude of the analysis field 403 -- x, and y and z -- each direction -- 0.3x0.2x2.6 micrometers -- carrying out -- the quality of the material of the triangular film -- gold, thickness = 30nm, and tip radius-of-curvature = -- it sharpened and 25nm was made into angle  $q_0 = 20$  degree. The incident wave 402 considered as the plane wave with a wavelength of 650nm, and the wave made it generate by putting a wave source 401 on the location which separated one wave from the film ( $L_2 = 650$ nm). The polarization direction of an incident wave was carried out in the direction of a x axis in drawing. Absorption boundary condition was used for the boundary condition of an analysis field in respect of being perpendicular to a periodic boundary condition and the z-axis in respect of being perpendicular to a x axis and the y-axis. Spacing ( $L_3$ ) of a metal membrane and a boundary made one wave spacing of one wave, a wave source, and a boundary. the number of mesh -- x, and y and z -- it was referred to as 60x50x60 in each direction, and mesh spacing near the top-most vertices of the triangle film was set to 2.5nm using the uniformity mesh to which spacing becomes small near the top-most vertices of the triangle film. Time amount unit width of face made the count of a count repeat 15000 times for 1x 10 to 18 seconds. The count result of drawing 5 (b) expresses the ratio of an approaching space light consistency (Inear) on the strength and the consistency (Iin) of an incident wave on the strength. Thus, the place of a light strong against the top-most-vertices 64 neighborhood occurs, and the maximum of the reinforcement becomes about 750 times by the ratio with incident light. Half-value width is set to X, the 15nm of each direction of Y, and 45nm. In addition, other metals may be used as a metal, for example, the intensity distribution same also in the case of silver are acquired, and strong maximum becomes about 590 times by the ratio with incident light. Moreover, since the configuration is similar, distribution of the approaching space light near the top-most vertices of the metal membrane which carried out the configuration of the above-mentioned ellipse is also considered to be the same as that of this result.

[0030] By the way, when the die length  $L_1$  of the above-mentioned triangle is below light wave length (for example,  $L_1 = 200$ nm), an approaching space light strong against about 65 top-most vertices other than radicalized top-most vertices occurs. Then, it is desirable to make the triangular die length  $L_1$  light hit only the top-most vertices 64 which made it larger than light wave length, such as 1 etc. micrometer, and were radicalized like drawing 7 (a). Or in order to make small approaching space light reinforcement in other two points other than top-most-vertices 64, the curvature of other two top-most vertices 68 may be enlarged like drawing 2 (d). In this case, the triangular die length  $L_1$  is good at below light wave length. For example, if the radius of curvature of top-most vertices 64 is 10nm, the radius of curvature of top-most vertices 68 will be set to 50nm or more, and die length  $L_1$  will be set to about 300nm. Since the degree of concentration of the electron to top-most vertices 68 becomes small by doing in this way, the approaching space light reinforcement generated there becomes weak. Moreover, the film 13 of the perimeter may be joined to the scatterer 70 which carried out the triangular configuration like drawing 2 (e). In this case, the curvature for a joint 71 is better than the radius of curvature of top-most vertices 64 to enlarge \*\*. Also in this case, the triangular die length  $L_1$  is good on below wavelength. For example, if the radius of curvature of top-most vertices 64 is 10nm, the radius of curvature for a joint 71 will be set to 50nm or more, and die length  $L_1$  will be set to about 300nm.

[0031] The thing in which another metal membrane 83 was formed on about 82 top-most vertices of the metal membrane 81 which carried out configurations in which the point was radicalized, such as a flat-surface ellipsoid and a triangle, as scatterer as shown in drawing 3 (a) may be used. For example, the radius of curvature of 15nm of top-most vertices and the film of a thickness 30nm triangle are formed, and the film with a thickness of 30nm which carried out the rectangular configuration is formed so that the spacing  $S_2$  with triangular top-most vertices may be set to 5nm. The radius of curvature of triangular top-most vertices should be 100nm or less, and thickness should just be 100nm or less. As for the kurtosis angle of top-most vertices, it is desirable to double with the excitation conditions of the after-mentioned plasmon. Thickness of the rectangular film is made the same as the thickness of the triangular film. Although spacing  $S_2$  should just be several 10nm or less, the smaller one is desirable in order to obtain high resolution. It is made for the polarization direction of incident light to turn to top-most vertices 82 like an arrow head 63, and it irradiates between top-most vertices 82 and film 83. At this time, polarization arises in top-most vertices 82 and each metal membrane up, and when those polarization interacts, an approaching space light strong between top-most vertices 82 and a metal membrane 83 occurs.

[0032] As shown in drawing 3 (b), as for especially the configuration of a metal membrane 83, it is desirable that it is the film 84 which carried out the configuration in which the point was radicalized like a flat-surface ellipsoid or a triangle like the metal membrane 81. Each top-most vertices 82 and 83 are arranged so that it may approach mutually. For example, the radius of curvature of 15nm of top-most vertices and two triangles with a thickness of 30nm are formed so that the spacing  $S_1$  of each top-most vertices may be set to 5nm. The radius of curvature of the top-most vertices of each triangle has the desirable one where 100nm or less and thickness are smaller in order to obtain high resolution, although the spacing  $S_3$  of 100nm or less and top-most vertices should just be several 10nm or less. It is made for the polarization direction of incident light to turn to top-most vertices 82 like an arrow head 63. Since very big polarization occurs in each of two metal membranes by doing in this way, an approaching space light very strong between two top-most vertices occurs as a result of those interactions. the approaching space light distribution generated near [ the ] the metal membrane when carrying out



incidence of the light to two triangles which countered drawing 6 -- FDTD -- the result calculated using law is shown. this count -- setting -- drawing 6 (a) -- like -- the magnitude of the analysis field 403 -- x, and y and z -- each direction --  $0.3 \times 0.2 \times 2.6$  micrometers -- carrying out -- the quality of the material of the triangular film -- gold, thickness = 30nm, and tip radius-of-curvature = -- it sharpened and 25nm was made into angle  $q_0 = 20$  degree. The incident wave 402 considered as the plane wave with a wavelength of 780nm, and the wave made it generate by putting a wave source 401 on the location which separated one wave from the film ( $L_2 = 780$ nm). The polarization direction of an incident wave was carried out in the direction of a x axis in drawing. Absorption boundary condition was used for the boundary condition of an analysis field in respect of being perpendicular to a periodic boundary condition and the z-axis in respect of being perpendicular to a x axis and the y-axis. Spacing ( $L_3$ ) of a metal membrane and a boundary made one wave spacing of one wave, a wave source, and a boundary. the number of mesh -- x, and y and z -- it was referred to as  $60 \times 50 \times 60$  in each direction, and mesh spacing near the top-most vertices of the triangle film was set to 2.5nm using the ununiformity mesh to which spacing becomes small near the top-most vertices of the triangle film. Time amount unit width of face made the count of a count repeat 15000 times for 1x 10 to 18 seconds. Drawing 6 (b) expresses distribution of the ratio of an approaching space light consistency (Inear) on the strength and the consistency (Iin) of an incident wave on the strength. Thus, the place of a light strong against spacing of top-most vertices 82 and 85 occurs, and the maximum of the reinforcement becomes about 5700 times by the ratio with incident light. As for half-value width, X and the direction of Y are set to 5nm. In addition, other metals may be used as a metal, for example, the intensity distribution same also in the case of silver are acquired, and strong maximum becomes about 5500 times by the ratio with incident light.

[0033] By the way, as mentioned above, as scatterer, when the dimension formed with the metal uses the film of the cone of nano meter order, a multiple cone, an ellipse, or a triangle, the approaching space light reinforcement generated near [ the ] the scatterer may be increased by exciting localization plasmon inside the scatterer. A dimension is the resonance state of the electron which the ellipsoid and tip radius of curvature below light wave length generate in the projection (the top-most vertices of a cone and the top-most vertices of the film of an ellipse or a triangle are equivalent to this) of the metal which was radicalized so that it might become below light wave length, and if localization plasmon occurs, near [ the ] the metal, the place of a very strong light will generate localization plasmon. Localization plasmon is excited by the light of specific wavelength and the resonance wavelength is decided by the polarization direction of a metaled class, a configuration, and excitation light. Therefore, it is desirable to set up these parameters so that a resonance wavelength may become close to the wavelength of the excitation light source. For example, when the configuration of scatterer can resemble a ball, a metal is gold, and 30 times of the consistency of incident light on the strength [ optical ] and the metal of a resonance wavelength are silver in 520nm as for the approaching space light consistency of the near on the strength, the approaching space light consistency of the near on the strength will be [ a resonance wavelength ] 480 times the consistency of incident light on the strength [ optical ] by 350nm. moreover, the configuration of scatterer -- major-axis: -- when it can approximate by the spheroid of minor-axis = 3:1, and a metal is gold, and 6500 times of the consistency of incident light on the strength [ optical ] and the metal of a resonance wavelength are silver in 650nm as for the approaching space light consistency of the near on the strength, the approaching space light consistency of the near on the strength will be [ a resonance wavelength ] 105 times the consistency of incident light on the strength [ optical ] by 500nm. However, it was assumed that the polarization direction of excitation light was parallel to the direction of a major axis of an ellipse when a metaled configuration is an ellipsoid. When a metaled configuration is a ball, since it is central symmetry, the polarization direction is arbitrary. This count result shows that a very strong approaching space light occurs near the metal membrane which carried out the configuration of an ellipse. Since the ratio of the die length of a major axis and a minor axis can also consider the configuration of the top-most vertices of a cone or a triangle to be a large ellipse in approximation, the enhancing effect of electric field comparable as an ellipse is expectable by optimizing the configuration and quality of the material.

[0034] In addition, when making the configuration of scatterer into a triangle, light may be irradiated so that a surface plasmon wave may be excited on a metal membrane. For that, as shown in drawing 7 (b), it is made for the polarization direction of light to become the plane of incidence of light, and parallel (p-polarized light), and  $q_1$  is adjusted whenever [ incident angle ] so that the wave number  $k_3$  of a surface plasmon wave may be in agreement with the direction component  $k_2$  of a field of the wave number vector  $k_1$  of incident light. For example, a metal consists of gold, and when membranous thickness is 40nm, it is made  $q_1 = 44.5$  degree. Carry out the triangular die length  $L_1$  more than light wave length, such as several micrometers, and it is made for the location of an optical spot to come on a metal membrane, and the direction of the plane of incidence of light is doubled so that a surface plasmon wave may advance toward top-most vertices 64. A strong approaching space light generates the surface plasmon wave produced on the metal membrane by doing in this way on the radicalized top-most vertices 64 at an assembly and about 64 top-most vertices.

[0035] Moreover, when using the metal membrane which carried out configurations in which the point was radicalized, such as a flat-surface ellipsoid and a triangle, as scatterer, as shown in drawing 8 (a), the metal membrane 91 may be formed in the substrate side face 94. It is made for the top-most vertices 92 which a strong approaching space light generates to touch the substrate base 93. The substrate side face 94 may become as [ incline / as shown in drawing 8 (b) / aslant ]. In this case, the incidence of the light 14 can be made to carry out in the direction perpendicular to a base 93. Moreover, in order to protect a metal membrane, a metal membrane top may be covered with a transparent dielectric.

[0036] Incidence of the convergence light 14 to the above-mentioned scatterer 12 is performed like drawing 9. In the example of drawing 9 (a), it is condensed with the objective lens 31 placed near the substrate, and incidence of the light is carried out to scatterer 12. In the example of drawing 9 (b), the configuration of a substrate 32 is made into the shape of a semi-sphere, and incidence of the light which condensed with the objective lens 31 is carried out to the substrate 32. By doing in this way, it becomes possible to raise NA of a lens and it can make the beam diameter in a focus still smaller than drawing 9 (a). The convergence device 33 of light, such as a holographic lens, is formed on a substrate, and it is made to be completed with scatterer 12 in the example of drawing 9 (c) by the parallel light which carries out incidence to a substrate. In the example of drawing 9 (d), a substrate is used as semi-sphere prism or a rectangular prism, and convergence light is made to carry out total reflection on the substrate front face of the part of scatterer 12. By doing in this way, the quantity of light of the background light which carries out incidence to a sample is reduced.

[0037] In addition, scatterer 12 may be formed in the end face of an optical resonator. For example, like drawing 10, film with light reflex nature, such as a metal membrane, is formed on a substrate 11, and then, film with light transmission nature, such as a dielectric, is formed so that thickness  $t_4$  may be set to  $t_4 n_4 = N \lambda / 2$  ( $n_4$ : the refractive index of a dielectric,  $\lambda$  = light wave length,  $N = 1$  or more integers). The film 13 which has scatterer 12 and reflexivity on it is formed. Thus, since the field strength of the light which carries out incidence to scatterer 12 by making resonator structure can be raised, the approaching space light reinforcement generated near the scatterer can be reinforced.



[0038] Moreover, scatterer 12 may be formed in the laser light outgoing radiation message on the barrier layer 52 of laser 51 like drawing 11. Semiconductor laser may be the thing of a field luminescence mold. While enabling this to reinforce approaching space light reinforcement the same with forming scatterer in the above-mentioned resonator end face, it becomes unnecessary to use a lens.

[0039] The above approaching space light probes are produced as follows.

[0040] First, as shown in drawing 12 (a), on a substrate 101, with a vacuum deposition machine, a sputtering system, etc., are the film 102, such as a metal, a dielectric, and a semi-conductor, and it is formed. Membranous thickness is made the same as the height of the scatterer to form (film formation).

[0041] Next, as shown in drawing 12 (b), the resist 103 for electron rays of a positive type is applied on the film. And as shown in drawing 12 (c), the part 104 which forms scatterer is exposed using an electron ray aligner, and it removes by attaching to a developer (exposure process).

[0042] Next, the film 102 of the exposed part 104 is removed like drawing 12 (d). An etching solution is used for membranous removal. For example, when forming the metaled film withgold, it etches using an aqua regia. If etching time is lengthened at this time, since an etching reagent will turn to the bottom of the resist film, a part larger than the exposed part 104 is removed. This die length s3 around which it turns is equivalent to the spacing s1 of the scatterer in drawing 1 (b), and the film. In addition, a plasma etching system may be used for membranous removal. However, it turns in this case, and since it is not etched, s3 is set to 0. Therefore, a probe with which the scatterer and the film like drawing 4 (d) touched is produced.

[0043] Next, it has a vacuum deposition machine, it is and a metal is made to deposit like drawing 12 (e). A metal accumulates on the part 104 from which the resist was removed by this, and scatterer 105 is formed (scatterer formation process).

[0044] Finally it attaches to the exfoliation liquid of a resist. The metal membrane 106 which this had deposited a resist and on it is removed, and a probe with the scatterer 105 and the film 102 like drawing 12 (f) is done.

[0045] In addition, when producing the scatterer of a cone form like drawing 2 (a), in the above-mentioned exposure process, a resist is exposed circularly (it is made for a radius to become below light wave length). In this case, since a metal turns and is full also in the opening 104 inside which was able to be opened in the resist as the thickness of a metal membrane 106 increases in case a metal membrane 106 is made to deposit on the resist film 103 in the above-mentioned scatterer formation process, the magnitude of opening becomes small gradually. Therefore, by continuing deposition of a metal membrane, as shown in drawing 13, the scatterer 111 of a cone form can be formed, until opening is closed.

[0046] In addition, in order to form metaled scatterer in the place which hollowed the substrate as shown in drawing 4 (a) and (c), a resist is applied on a direct substrate and the substrate etching process which etches a substrate is added without the first film formation process instead of a membranous etching process. In this case, when using what does not have conductivity, such as a quartz, as a substrate, in order to prevent charging a substrate and a production pattern spreading in the case of exposure by the electron ray, a transparent membrane with the conductivity of 10nm or less of thickness numbers, for example, ITO etc., is formed using the spatter or the vacuum deposition method on the substrate before resist spreading.

[0047] The above-mentioned approaching space light probe may be produced as follows.

[0048] First, as shown in drawing 14 (a), on a substrate 101, with a vacuum deposition machine, a sputtering system, etc., are the film 102, such as a metal, a dielectric, and a semi-conductor, and it is formed. Membranous thickness is made the same as the height of the scatterer to form.

[0049] As shown in drawing 14 (b) below, the film 123 of the part which forms scatterer is removed using photolithography or electron-beam lithography.

[0050] Next, as shown in drawing 14 (c), the electron beam resist of a positive type is applied, and as shown in drawing 14 (d), with an electron ray aligner, the part 125 which forms scatterer is and is exposed. After exposure removes the resist of the part 125 exposed by attaching to a developer.

[0051] Next, a vacuum deposition machine is used and a metal is made to deposit on the resist film, as shown in drawing 14 (d). Thereby, scatterer 105 is formed in the part 125 from which the resist was removed.

[0052] Finally, the metal membrane 127 formed the resist film 124 and on it is removed by attaching to the exfoliation liquid of a resist.

[0053] In addition in order to form metaled scatterer in the place which hollowed the substrate as shown in drawing 4 (a) and (c), the first film formation process is lost and the process which forms a direct hollow in a substrate front face using photolithography etc. is added.

[0054] Moreover, the above-mentioned approaching space light probe may be produced like next.

[0055] First, as shown in drawing 15 (a), on a substrate 101, with a vacuum deposition machine, a sputtering system, etc., are the film 102, such as a metal, a dielectric, and a semi-conductor, and it is formed. Membranous thickness is made the same as the height of the scatterer to form.

[0056] Next, as shown in drawing 15 (b), the electron beam resist of a positive type is applied on the film 102. And as shown in drawing 15 (c), the part 134 equivalent to the part 16 between the scatterer 12 in drawing 1 and the film 13 is exposed using an electron ray aligner. The resist of the part 134 exposed by attaching to a developer is removed after exposure.

[0057] Next, as shown in drawing 15 (d), an etching solution or plasma etching removes the film 102 of a part 134 from which the resist was removed.

[0058] Finally, as shown in drawing 15 (e), the resist film 133 is removed.

[0059] moreover, the above-mentioned approaching space light probe -- \*\*\*\* for negatives resist -- you may produce as follows.

[0060] First, as shown in drawing 16 (a), negative resist 141 is applied on a substrate 101. When using what does not have conductivity, such as a quartz, as a substrate, in order to prevent charging a substrate and a pattern spreading in the case of exposure by the electron ray, before applying a resist, a transparent membrane with conductivity, for example, ITO etc., is formed on the substrate (thickness is several 10nm).

[0061] Next, as shown in drawing 16 (b), resists other than partial 142 equivalent to the part 16 between the scatterer 12 in drawing 1 and the film 13 are removed by using for electron beam lithography.

[0062] Next, a metal membrane is made to deposit using a vacuum deposition machine, as shown in drawing 16 (c). Thereby, scatterer 105 and the film 144 around it are formed.

[0063] Finally, as shown in drawing 16 (d), the metal membrane 143 deposited the resist film 142 and on it is removed by attaching to resist exfoliation liquid.

[0064] In addition, as shown in drawing 4 (b) and (c), scatterer 12 produces as follows the approaching space light probe protected by the

dielectric 22.

[0065] First, as shown in drawing 17 (a), on scatterer 12 and the film 13 around it, a vacuum evaporation system or a sputtering system is used, and a dielectric film 151 is formed.

[0066] Next, as shown in drawing 17 (b), it removes by grinding except 22 between scatterer 12 and the film 13 around it using an abrasive material. As an abrasive material, for example, a diamond slurry, an alumina slurry, or a silica slurry is used.

[0067] By the way, in case the above-mentioned approaching space light probe is brought close to a sample and a sample is made to scan, the location of a probe is changed with the irregularity of a sample. When applying to optical recording/regenerative apparatus especially, the location of a probe will be sharply changed by the inclination of a disk, or distortion. Consequently, the location of the light which carries out incidence to a probe will shift, and the amount of the light which shines upon metaled scatterer will be changed. In order to prevent this, the device which carries out regulating automatically so that the location of the focus of incident light may always come to the location of metaled scatterer is required. The approach is shown below.

[0068] As shown in drawing 18, a grating, a Wollaston prism, etc. divide a collimated beam 1600 into the beam of two or more \*\* using 1604. On the probe, the mark for focusing is prepared beside scatterer, and it is made in charge [ one in the divided beam / other beams ] of the mark for focusing in scatterer 1609. It reflects in this mark for focusing, and a focal location is adjusted by measuring the configuration of the light beam which has returned.

[0069] Specifically, equipment is constituted as follows. As shown in drawing 19 (a), width of face is smaller than the diameter of an optical spot by side of scatterer 1702, and the depth establishes two  $\lambda/8n$  ( $\lambda$ :light-wave length,  $n$ : refractive index of a substrate) long and slender slots in it (1701 1703). It is made, as for these two slots, for a direction to intersect perpendicularly mutually. A light beam is divided into three using a grating, a Wollaston prism, etc., and it is made for one 1705 to hit scatterer 1702 otherwise [ two ] inside at the core of 1704 and the 1706 fang furrows 1701 and 1703. After dissociating with incident light by the beam splitter 1603, incidence of the reflected light of these three beams is carried out to a detector 1607 after passing a convex lens 1605 and the cylinder lens 1606. As a detector 1607 has three light-receiving sides and it is shown in drawing 19 (b), one 1707 is divided into four among outside light-receiving sides, and the light-receiving side 1703 of another outside is divided into two.

[0070] Alignment of a direction parallel to a substrate side is performed as follows. The configuration of the light beam on the light-receiving sides 1707 and 1708 and 1709 becomes like 1710, 1711, and 1712. The main beam 1711 is the reflected light from scatterer, and is the reflected light from the beam 1710 of the width, and 1712 fang furrows. When the diffracted light generated in a slot interferes, the pattern of the reflected light from a slot has two bright parts, as shown in drawing 19 (b). When the focal location is correct, the brightness of these two parts becomes equal mutually, but if a focal location shifts, as shown in drawing 19 (c), a difference will arise in the brightness of two parts. Therefore, a focal location can be doubled by controlling so that the brightness of two parts becomes equal (it controls so that the signal from a detector is set to  $(A+C)-(B+D)=0$  and  $E-F=0$ ).

[0071] If it adjusts so that circle of least confusion may be formed on a detector when the alignment of a direction perpendicular to a substrate side inserts in detection optical system the optic made to generate astigmatism, such as a cylindrical lens, for example, using an astigmatism method and the focal location is correct, at the time of a focus, the configuration of return light will become circle-like like drawing 19 (b). However, if a focal location shifts, since return light will turn into un-parallel light, the configuration of the light which passed the convex lens 1605 and the cylinder lens 1606 becomes ellipse-like as shown in drawing 19 (d). Therefore, a focal location can be doubled by controlling so that the configuration of a beam becomes a circle (it controls so that the signal from a detector is set to  $(A+D)-(B+D)=0$ ).

[0072] The application to the optical recording/regenerative apparatus of the above-mentioned approaching space probe is shown in drawing 20 (a). An approaching space light probe is carried in the optical head 1802 in which an objective lens, the light source, a detector, etc. were carried. The optical head is brought close to a disk 1801. An optical head is moved to radial [ of a disk ] using the carriage actuator 1803. The optical system inside an optical head is constituted like drawing 20 (b). Outgoing radiation light is made the light source at a circular collimated beam using a collimator lens 1810 and the beam plastic surgery prism 1811 using semiconductor laser 1809. Incidence of this beam is carried out to the approaching space light probe 1804 after passing the grating 1812 used for focusing, a polarization beam splitter 1813, the quarter-wave length version, a mirror 1801, and an objective lens 1807. The location of an objective lens is adjusted using an actuator 1808. Moreover, an actuator 1806 is used in order to tune the location of an approaching space light probe finely for tracking. The probe 1804 is attached in the suspension 1805 and pushed against a disk 1801 by the force of this suspension. After a polarization beam splitter 1813 dissociates with incident light and the reflected light from a probe passes a condenser lens 1815 and the cylinder lens 1816 for alignment, incidence of it is carried out to a detector 1817.

[0073] In the above recording apparatus, since the recording layer is shown on the record disk front face, when removing and carrying a disk 1801 from the optical head 1802, it has the danger that record data will no longer be reproduced with the blemish and dirt which are attached to a disk. In order to prevent this, it is good to contain a disk 1801 and the approaching space light probe 1804 in a cartridge 1900, as shown in drawing 21, and to intercept a disk front face and an approaching space light probe with the open air. For example, as shown in drawing 21 (b), an arm 1904 is attached in the revolving shaft prepared in the angle of a cartridge, and a suspension 1805 and the approaching space light head 1801 are attached in the arm. Tracking rotates a revolving shaft 1905 and is performed by moving an arm 1904. The optical head body 1903 containing the light source or a detector is placed out of a cartridge, and the light 1902 from an optical head body lets the transparent aperture 1901 pass, and it introduces it into the approaching space light probe 1804. At this time, it is made for light 1902 to turn into parallel light, and with the condensing device formed on the probe like drawing 9 (c), the light which carried out incidence to the probe is, and is condensed. The optical head body 1903 is attached in the arm 1907 driven with the rotation actuator 1908, and is joined to the revolving shaft 1905 with which this arm was connected with the approaching space light probe. Thereby, an optical head body and an approaching space light probe interlock and move. In order to join the revolving shaft 1905 connected with the approaching space light probe, and the arm 1907 in which the optical head body was attached with a sufficient precision, as shown in drawing 21 (c), the projection 1910 of the shape of V groove 1909 and a semi-sphere is used. That is, V groove 1909 is attached in the revolving-shaft 1905 upper part, and the semi-sphere-like projection 1910 is attached in the lower part of the arm 1907 of an optical head body. By forcing the semi-sphere-like projection 1910 on V groove 1909, the arm 1907 and revolving shaft 1905 of an optical head body are joined.

[0074] In addition, when using the probe which had the metal membrane which carried out configurations in which the point was radicalized, such as a triangle and a flat-surface ellipsoid, in the substrate side face like a probe with the scatterer of the conic metal like drawing 2 (a), or drawing 8, as shown in drawing 22 (a) and (b), it is good to prepare a metal layer in the bottom of the recording layer in a

disk. For example, the metal layers 2001, such as gold and silver, are formed on the disk substrate 2003, and the record membrane layers 2000, such as a phase change medium with a thickness of about 5nm, are formed on it. Thus, if a metal membrane is formed into a disk, in order that polarization generated in the metaled scatterer 12 and polarization generated in 2001 in a metal membrane may interact, the approaching space light reinforcement between a metaled scatterer tip and a metal membrane is reinforced. Therefore, effectiveness can be raised.

[0075]

[Effect of the Invention] Since the approaching space light probe of this invention generates approaching space light with the scatterer of the metal which carried out the configuration of a cone, many cones, a flat-surface ellipsoid, or a triangle, a very strong approaching space light can be generated. Moreover, a high speed can be made to scan a probe, since film, such as a metal with the same thickness as the height of the scatterer formed around scatterer, a dielectric, or a semi-conductor, is formed, without destroying scatterer. Moreover, background light can be reduced by making the membranous quality of the material into a thing with protection-from-light nature, and making spacing of scatterer and the film below into light wave length.

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[Translation done.]

## \* NOTICES \*

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

## DESCRIPTION OF DRAWINGS

## [Brief Description of the Drawings]

[Drawing 1] drawing showing the whole approaching space light probe structure of this invention -- the (a) perspective view and the (b) sectional view.

[Drawing 2] The triangle which are the (a) cone, (b) flat-surface ellipsoid, the (c) triangle, and a triangle with the larger radius of curvature of two top-most vertices than the remaining top-most vertices and (d) (e) circumference with the perspective view showing the configuration of the metal scatterer of this invention and which was joined when wound.

[Drawing 3] That in which the metal membrane was formed near the top-most vertices of the (a) triangle with the perspective view showing the configuration of the metal scatterer of this invention, the thing in which another triangle was formed near the top-most vertices of the (b) triangle.

[Drawing 4] What formed the hollow in the substrate instead of forming (a) film with the sectional view showing the whole approaching space light probe structure of this invention, (b) The thing and (c) which filled between scatterer and film with the transparent dielectric. What formed the hollow in the substrate instead of forming the film, and formed the transparent dielectric around scatterer, thing which formed the film of a dielectric so that spacing might not open between (d) scatterers.

[Drawing 5] the approaching space light intensity distribution generated when incidence of the light is carried out to a triangular metal membrane -- the (a) count approach and (b) count result (what plotted the ratio with incident light reinforcement).

[Drawing 6] the approaching space light intensity distribution generated when incidence of the light is carried out to the metal membrane of two triangles which counter -- the (a) count approach and (b) count result (what plotted the ratio with incident light reinforcement).

[Drawing 7] The perspective view of the incidence approach of the light to a triangle, the approach of irradiating light only at the tip of (a), the approach of carrying out incidence of the light so that surface plasmon may occur on the (b) metal membrane.

[Drawing 8] (a) The perspective view of the probe in which the triangular film was formed on the substrate side face, and (b) Perspective view of the probe in which the triangular film was formed on the substrate side face deleted aslant.

[Drawing 9] The approach of condensing light with the lens put on (a) exterior with the sectional view showing the incidence approach of the light to the approaching space light probe of this invention, the thing which made the (b) substrate the shape of a semi-sphere, the thing which formed the holographic lens in the shape of a (c) substrate, the thing to which incidence of the (d) light was carried out so that total reflection conditions might be fulfilled.

[Drawing 10] It is a sectional view although metaled scatterer was formed in the optical-resonator end face.

[Drawing 11] It is a sectional view although metaled scatterer was formed in the end face of semiconductor laser.

[Drawing 12] the mimetic diagram which shows the production process of an approaching space optical fiber probe -- it is -- (a) film formation stroke, (b) resist spreading stroke, (c) exposure, a development stroke, the etching stroke of (d) film, and (e) A scatterer formation stroke and (f) resist removal stroke are shown.

[Drawing 13] The mimetic diagram showing the formation approach of the scatterer which carried out the configuration of a cone or a multiple drill.

[Drawing 14] the mimetic diagram which shows the production process of an approaching space optical fiber probe -- it is -- (a) film formation stroke, (b) hollow formation stroke, (c) resist spreading stroke, (d) exposure, a development stroke, and (e) A scatterer formation stroke and (f) resist removal stroke are shown.

[Drawing 15] the mimetic diagram which shows the production process of an approaching space optical fiber probe -- it is -- (a) metal membrane formation stroke, (b) resist spreading stroke, (c) exposure, a development stroke, the etching stroke of the (d) metal membrane, and (e) A resist removal stroke is shown.

[Drawing 16] It is the mimetic diagram which shows the production process of an approaching space optical fiber probe, and (a) resist spreading stroke, (b) exposure development stroke, the vacuum evaporatio stroke of the (c) metal, and (d) resist removal stroke are shown.

[Drawing 17] It is the mimetic diagram which shows the production process of a probe which wrapped the scatterer circumference in the transparent dielectric, and (a) dielectric film formation and (b) dielectric film polish stroke are shown.

[Drawing 18] It is the mimetic diagram showing the automatic-focusing centering-control approach.

[Drawing 19] It is the mimetic diagram showing the relation between the mark for justification in the automatic-focusing centering-control approach, and a light beam, and the relation between a detector and a light beam. (a) The configuration of the mark formed on a probe, the physical relationship of a beam, and (b) The configuration of the beam on a detector when the configuration of a detector and a focal location suit, (c) The configuration of the beam on a detector when the location of a light beam shifts horizontally to the substrate side of a probe, and (d) The configuration of the beam on a detector when the location of a light beam shifts perpendicularly to the substrate side of a probe is shown.

[Drawing 20] the perspective view showing the equipment configuration when applying the approaching space light probe of this invention to optical recording/regenerative apparatus -- the configuration of the whole (a), and (b) Optical system is shown.

[Drawing 21] The perspective view showing the V groove for joining the arm inside the perspective view in which showing an optical disc cartridge with a built-in approaching space light probe, and showing the whole (a) configuration, the (b) sectional view, and the (c) cartridge, and the arm of the cartridge exterior, and a semi-sphere projection.

[Drawing 22] The perspective view in the case of using the probe which has the triangular film in the sectional view in the case of using the probe which shows the approaching space optical recording / the playback approach using an optical disk with a metal membrane, and has the scatterer of a (a) conic metal, and (b) substrate side face.

[Description of Notations]

Eleven substrates

Scatterer of 12 metals

Film of 13 metals, a dielectric, or a semi-conductor

14 incident light

15 record disk

Between 16 scatterers and the film of the perimeter

The hollow formed in 21 substrate front face

The dielectric formed in the perimeter of 22 scatterers

Film of 23 dielectrics

31 condenser lenses

32 semi-sphere substrate

33 grating lens

34 semi-sphere prism or a rectangular prism

41 reflective film

42 dielectric layers

51 semiconductor laser

52 barrier layers

61 top-most vertices

62 top-most vertices

The polarization direction of 63 incident light

Top-most vertices which were radicalized 64 times

Top-most vertices other than the top-most vertices which were radicalized 65 times

Top-most vertices where 68 radius of curvatures are big

70 triangle film

A part for a joint with bigger radius of curvature than the radius of curvature of 71 top-most vertices

Film which carried out the configuration of 81 triangles or an ellipse

82 top-most vertices

83 metal membranes

Film which carried out the configuration of 84 triangles or an ellipse

85 top-most vertices

Film which carried out the configuration of 91 triangles or an ellipse

92 top-most vertices

93 substrate base

94 substrate side face

101 substrates

Film of 102 metals, a dielectric, or a semi-conductor

103 resists

The part exposed 104 times

105 scatterer

The metal membrane of 106 metals

Scatterer of the metal which carried out the configuration of 111 cones or a multiple drill

The hollow formed by removing 123 film

124 resists

The part exposed 125 times

127 metal membranes

133 resists

The part exposed 134 times

141 resists

The part exposed 142 times

143 metal membranes

144 metal membranes

Film of 151 dielectrics

401 wave sources

402 incident light

403 analysis field

1600 incident light

1601 contiguity place light probe

1602 objective lenses

1603 beam splitters

1604 gratings or a Wollaston prism

1605 convex lenses

1606 cylinder lens

1607 detectors

Method mark of 1701 focal alignment

1702 scatterer  
Method mark of 1703 focal alignment  
The location of 1704 light beams  
The location of 1705 light beams  
The location of 1706 light beams  
1707 quadrisection detector  
1708 detectors  
1709 two-piece-housing detector  
The pattern of the return light from the method mark of 1710 focal alignment  
The pattern from the return light from 1711 scatterers  
The pattern of the return light from the method mark of 1712 focal alignment  
1801 record disk  
1802 light head  
1803 carriage actuator  
1804 contiguity place light probe  
1805 suspensions  
1806 actuators  
1807 objective lenses  
1808 actuators  
1809 semiconductor laser  
1810 KORIME ? Tollens  
1811 beam plastic surgery prism  
1812 gratings or a Wollaston prism  
1813 polarization beam splitters  
The 1814 quarter wavelength version  
1815 convex lenses  
1816 cylinder lens  
1817 detectors  
1900 cartridges  
1901 apertures  
1902 incident light  
1903 light head body  
1904 arms  
1905 revolving shafts  
1906 joints  
1907 arms  
1908 rotation actuator  
1909 V grooves  
1910 anti-spherical projection  
2000 record membrane layer  
2001 metal membrane layers  
2003 substrates.

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[Translation done.]

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1. This document has been translated by computer. So the translation may not reflect the original precisely.
2. \*\*\*\* shows the word which can not be translated.
3. In the drawings, any words are not translated.

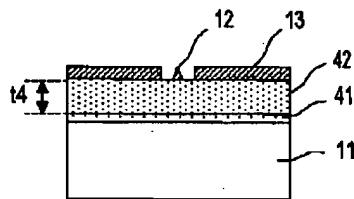
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DRAWINGS

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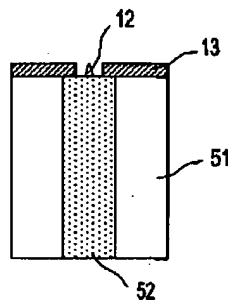
[Drawing 10]

図 10



[Drawing 11]

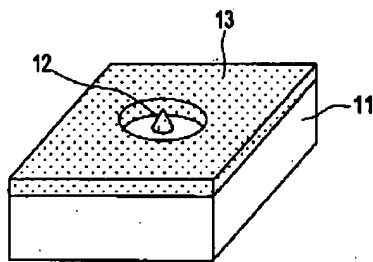
図 11



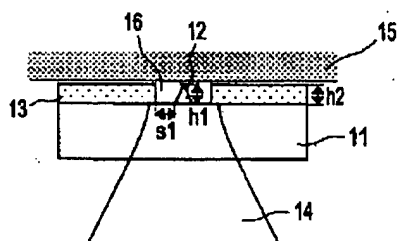
[Drawing 1]



圖 1



**(a)**



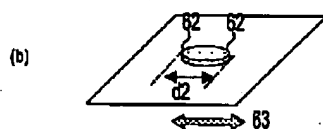
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[Drawing 2]

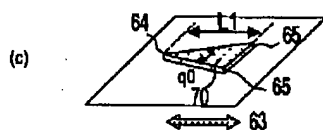
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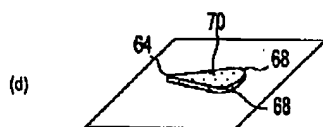
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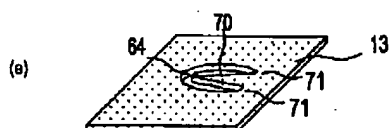
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(c)



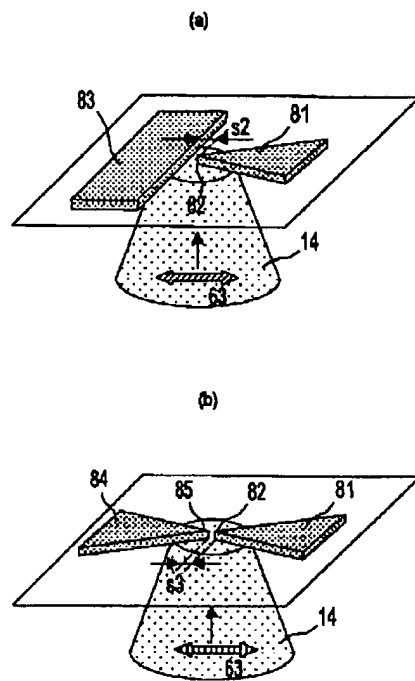
(d)



(8)

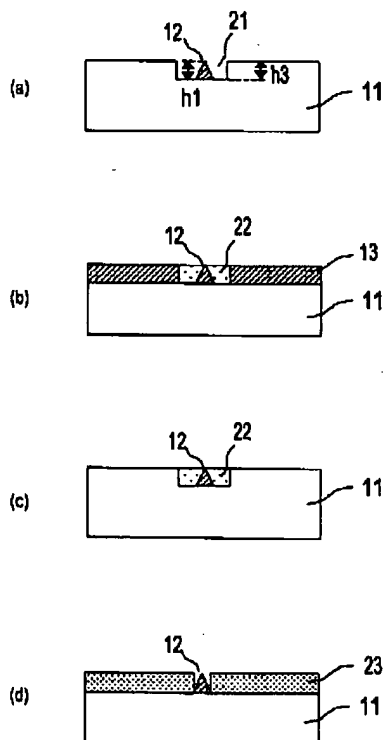
[Drawing 3]

図 3



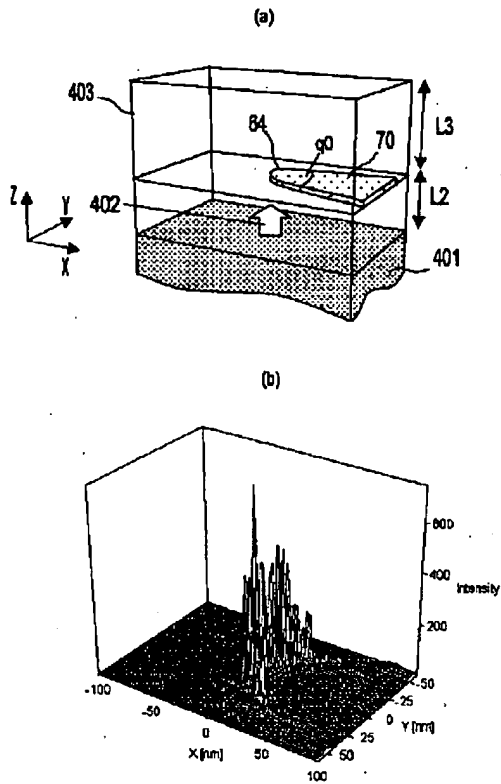
[Drawing 4]

図 4



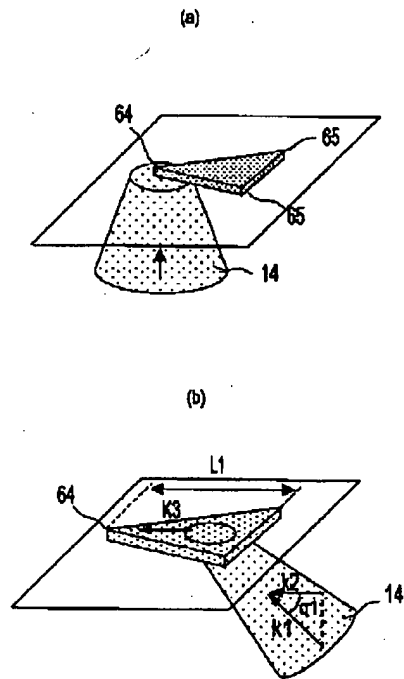
[Drawing 5]

图 5



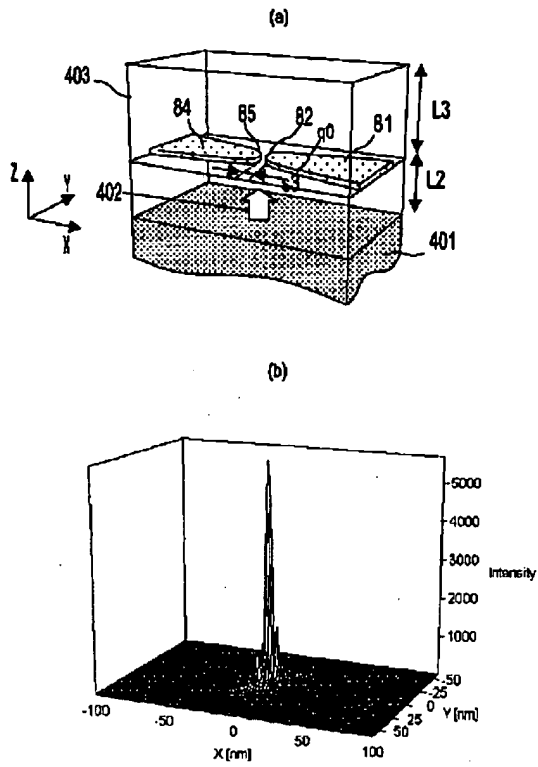
[Drawing 7]

图 7



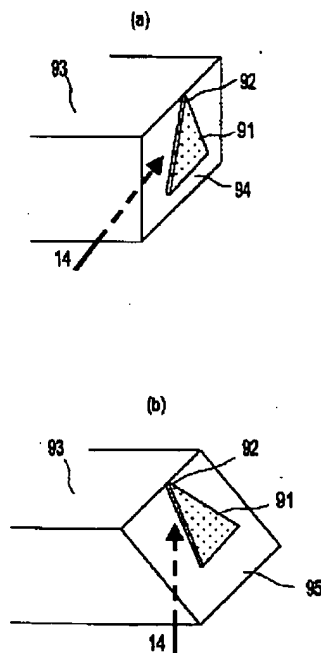
[Drawing 6]

図 6

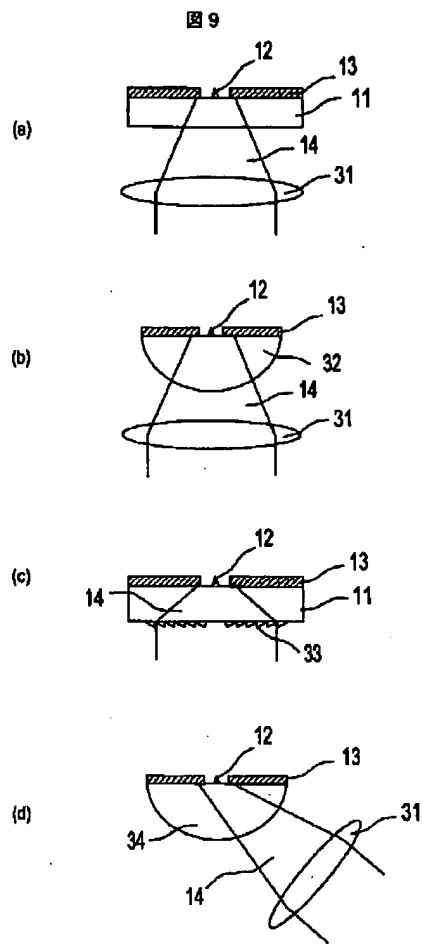


[Drawing 8]

図 8

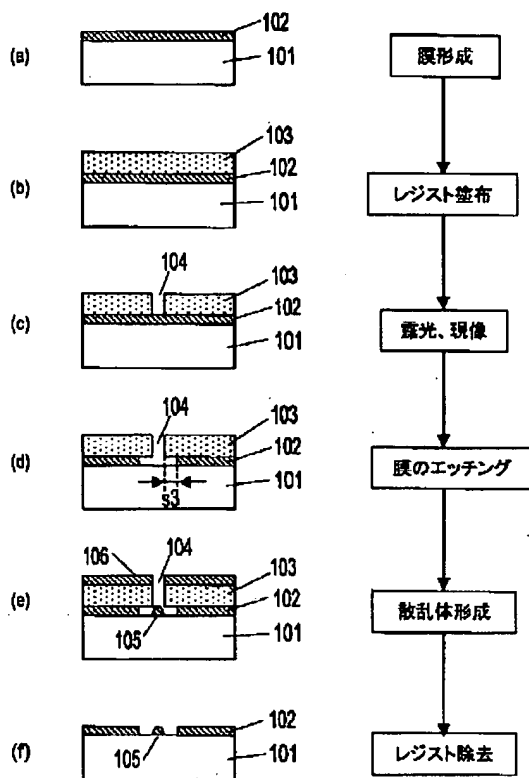
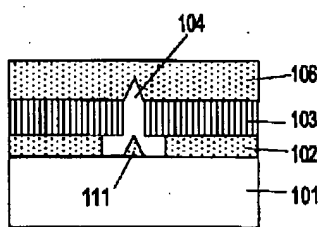


[Drawing 9]



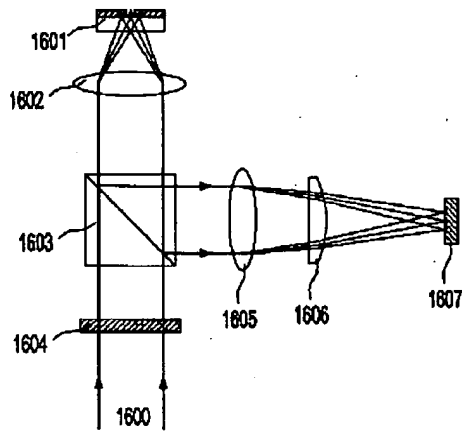
[Drawing 12]

図 12

[Drawing 13]  
図 13

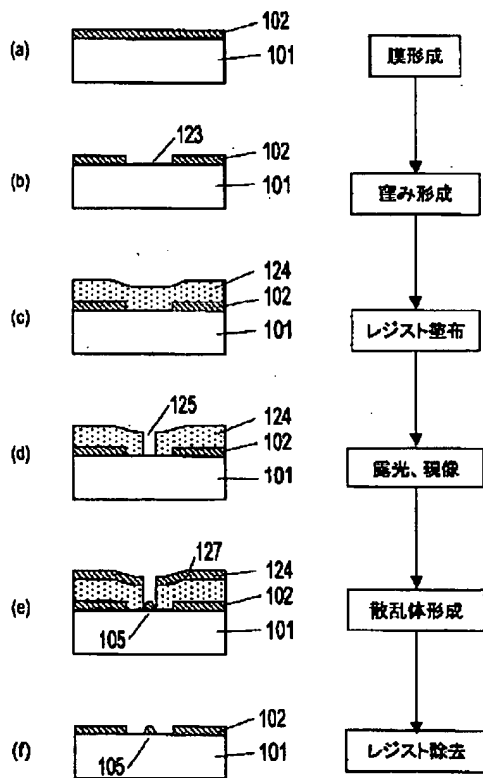
[Drawing 18]

図 18



[Drawing 14]

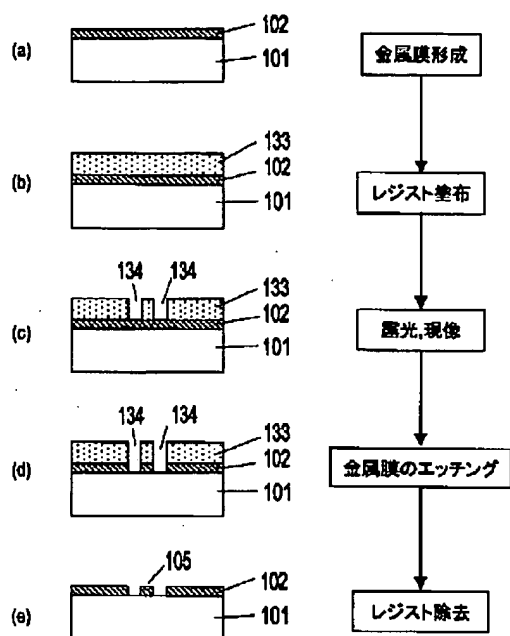
図 14



[Drawing 15]

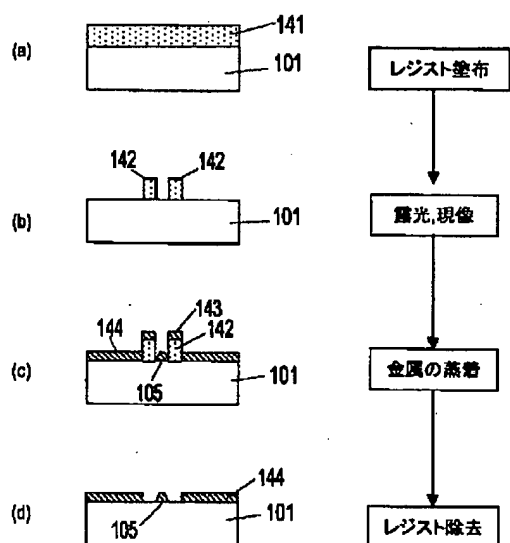


図 15



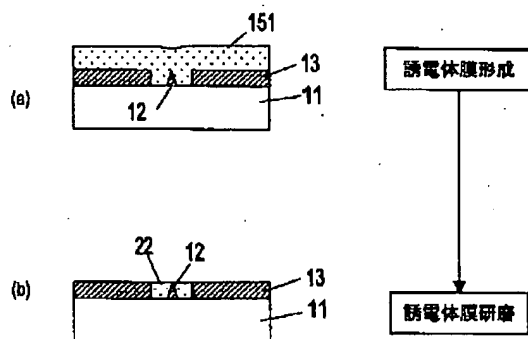
[Drawing 16]

図 16



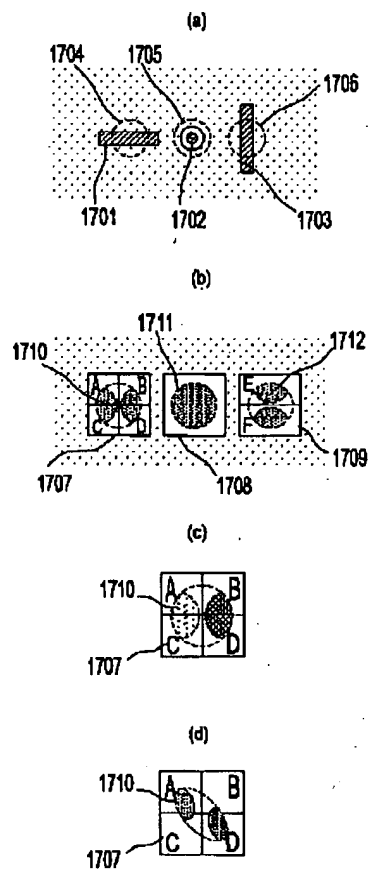
[Drawing 17]

図 17



[Drawing 19]

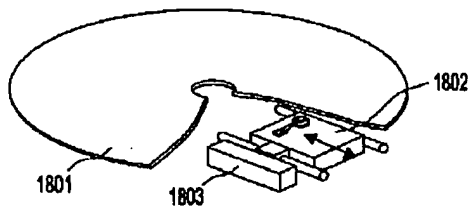
図 19



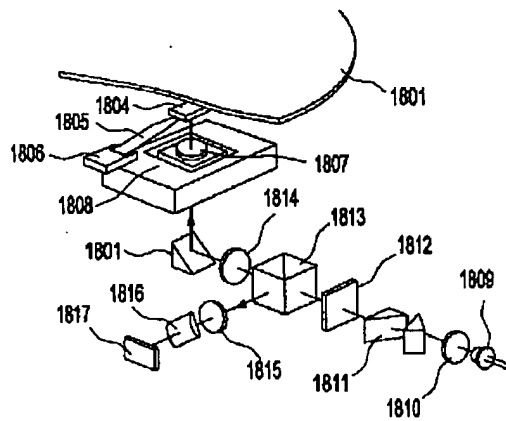
[Drawing 20]

20.

(a)

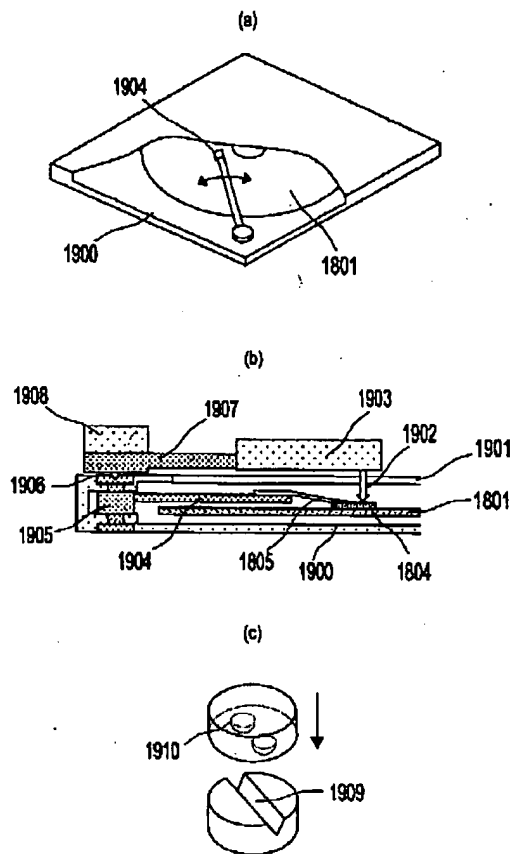


(b)



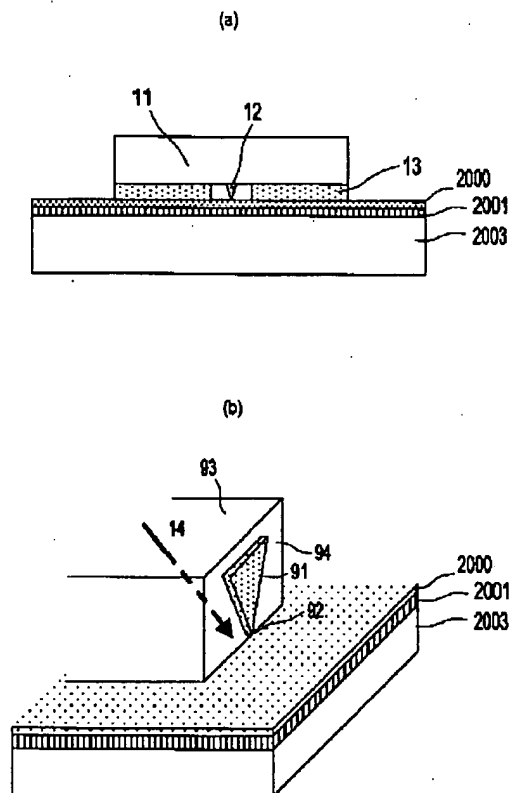
[Drawing 21]

図 21.



[Drawing 22]

図 22.



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[Translation done.]

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CORRECTION OR AMENDMENT

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[Kind of official gazette] Printing of amendment by the convention of 2 of Article 17 of Patent Law  
 [Section partition] The 1st partition of the 6th section  
 [Publication date] November 18, Heisei 16 (2004. 11.18)

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 [Date of Publication] September 21, Heisei 13 (2001. 9.21)  
 [Application number] Application for patent 2000-73922 (P2000-73922)  
 [The 7th edition of International Patent Classification]

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 G01N 13/10  
 G02B 3/00  
 G02B 5/00  
 G02B 5/32  
 G11B 7/135  
 G12B 21/06

[FI]

G01N 13/14	B
G01N 13/10	G
G02B 3/00	Z
G02B 5/00	Z
G02B 5/32	
G11B 7/135	A
G12B 1/00	601 C

[Procedure revision]  
 [Filing Date] November 21, Heisei 15 (2003. 11.21)  
 [Procedure amendment 1]  
 [Document to be Amended] Specification  
 [Item(s) to be Amended] Claim  
 [Method of Amendment] Modification  
 [The contents of amendment]  
 [Claim(s)]  
 [Claim 1]

Scatterer of the metal with which the shaft carried out the configuration of a perpendicular cone or a multiple drill to the substrate front face substantially on the substrate

The approaching space light probe characterized by \*\*\*\*(ing) and exciting plasmon inside said scatterer.

[Claim 2]

The approaching space light probe characterized by for the die length of a major axis and a minor axis and thickness having the scatterer of the metal which carried out the configuration of the flat-surface ellipsoid which is below light wave length, and exciting plasmon inside said scatterer on a substrate.

[Claim 3]

The approaching space light probe characterized by for thickness and the radius of curvature of top-most vertices having the scatterer of the metal which carried out the configuration of the triangle below light wave length, and exciting plasmon inside said scatterer on a substrate.

[Claim 4]

The approaching space light probe which the metal membrane which carried out the configuration in which the point was radicalized and the metal membrane of the configuration of arbitration which produce plasmon resonance are formed on a substrate, and is characterized by spacing of radicalized top-most vertices and another metal membrane being 50nm or less.

[Claim 5]

The approaching space light probe which two metal membranes which produce plasmon resonance, and which carried out the configuration in which the point was radicalized are formed on a substrate, and is characterized by spacing of radicalized top-most vertices being 50nm or less.

[Claim 6]

The approaching space light probe according to claim 1 to 5 characterized by having the metal membrane, dielectric film, or semiconductor film which has the same thickness as the height of scatterer around said scatterer.

[Claim 7]

The optical recording/regenerative apparatus characterized by using an approaching space light probe according to claim 1 to 6.

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[Translation done.]